Effects of imidacloprid (Merit® 2F) on physiology of woody plants and performance of twospotted spider mite, fall webworm, and imported willow leaf beetle

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Summary

We have shown that imidacloprid (Merit® 2F) can have growth enhancing effects on hybrid poplars that are independent of its insecticidal properties by increasing total leaf area. To test the generality of this pattern, a factorial experiment was conducted to evaluate the effects of imidacloprid on growth, biomass allocation, and gas exchange of the woody plants *Populus nigra*, *Euonymus alatus*, *Betula nigra*, and *Salix sericea* under high and low fertilization regimes. Laboratory bioassays were performed to test the effects of imidacloprid on the performance of twospotted spider mite (*Tetranychus urticae*), imported willow leaf beetle (*Plagiodera versicolora*), and fall webworm (*Hyphantria cunea*). After 44 days of exposure, imidacloprid significantly increased total plant biomass and total leaf area of *P. nigra,* but had no effect on the three plant species, suggesting that the growth-enhancing effects of imidacloprid are species specific. Imidacloprid increased the fecundity of twospotted spider mite on *E. alatus* in the low fertility treatment, raising egg production to levels observed in the high fertility treatment. As expected, imidacloprid decreased survival of imported willow leaf beetle on *S. sericea*. Surprisingly, imidacloprid also decreased larval growth and survival of fall webworm on *B. nigra*, *S. sericea,* and *P. nigra*.

Introduction

We have shown that the neonicotinoid insecticide imidacloprid can increase the growth of *P. nigra* in stressful and optimal environments (Chiriboga et al., 2007), a pattern that has also been observed in some crops (Thielert, 2006). However, the generality of the growth-enhancing effects on woody plants has not been investigated. Imidacloprid also can have variable effects on arthropods. Recent studies suggest that enhanced vigor of treated plants may increase spider mite populations (Raupp et al., 2004). However, imidacloprid is thought to have limited effects on Lepidoptera, but strong negative effects on leaf beetles.

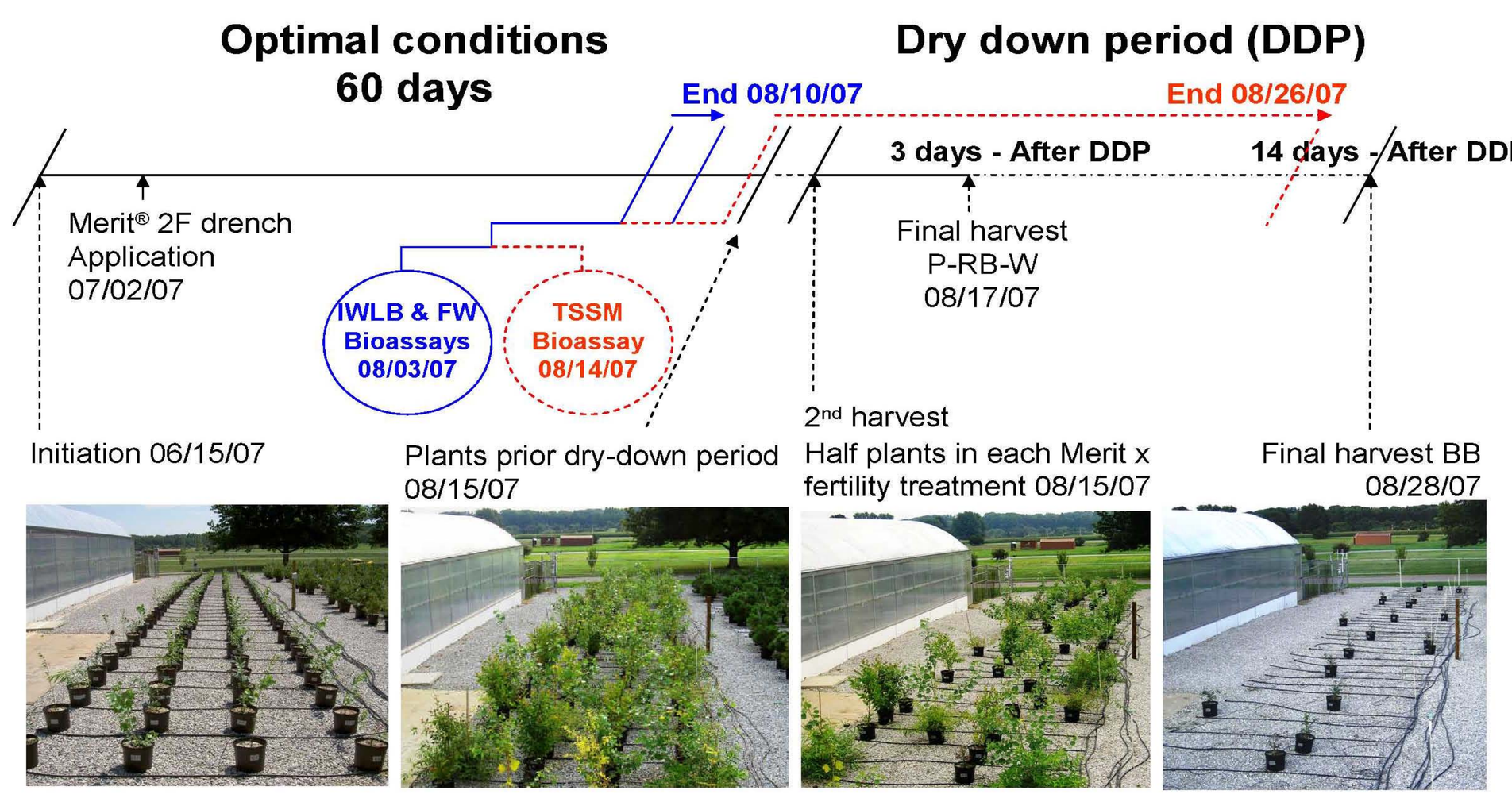
Objectives

1. To test the generality of growth-enhancing effects of Merit® 2F on hybrid poplar (*P. nigra* clone NC5271), river birch (*B. nigra*), burning bush (*E. alatus*), and willow (S. *sericea*).
2. To evaluate the performance of twospotted spider mite, fall webworm, and imported willow leaf beetle through laboratory bioassays.

Methods

From June through August 2007, a computer-controlled fertigation system delivered two fertilization treatments (30 and 150 ppm N) which were crossed in factorial combination with Merit® 2F drench (labeled rate) application. A dry-down period was established to test effects of imidacloprid on drought stress tolerance. Laboratory bioassays were performed using excised foliage from the woody species to test for effects on arthropods.

Timeline methodology



BB = Burning Bush; P = Poplar ; RB = River Birch; W = Willow
IWLB = Imported Willow Leaf Beetle; FW = Fall Webworm; TSSM = Twospotted Spider Mite

Results and Discussion

After 44 days of exposure, Merit® 2F significantly increased the total biomass of *P. nigra* by 23% and total leaf area by 18% (Fig.1).

A significant Merit® 2F × fertility interaction for total number of leaves and avg. leaf size indicates that the positive effects of Merit® 2F were dependent on fertilization rate (Fig.1).

Merit® 2F had no effect on growth or biomass allocation of *B. nigra, E. alatus* and *S. sericea*, which suggests that positive effects of imidacloprid on plant physiology are species specific (Table 1).

Response variables	*B.nigra*		*E. alatus*		*S. sericea*	
	Merit® 2F	Untreated	Merit® 2F	Untreated	Merit® 2F	Untreated
Total mass (g)	124 ± 15a	107 ± 15a	40 ± 2.1a	40 ± 2.1a	223 ± 2.6a	240 ± 2.6a
Total leaf area (cm^2)	9604 ± 1441a	8490 ± 1441a	653 ± 37a	637 ± 37a	13618 ± 774a	15354 ± 774a
Total leaves	543 ± 72a	550 ± 72a	79 ± 5.7a	89 ± 5.7a	1100 ± 105a	1256 ± 105a
Average leaf size (cm^2)	18 ± 0.6a	15 ± 0.6a	8.5 ± 0.5a	7.4 ± 0.5a	12 ± 0.7a	12 ± 0.7a
Percent root mass	14 ± 1.0a	13 ± 1.0a	40 ± 1.2a	41 ± 1.2a	22 ± 1.4a	21 ± 1.4a

Table 1. Effects of Merit® 2F on growth and biomass allocation of *Betula nigra, Euonymus alatus,* and *Salix sericea* (least square mean ± SE). Means within the imidacloprid treatment with the same letter are not significantly different (ANOVA followed by LSD test, p<0.05).

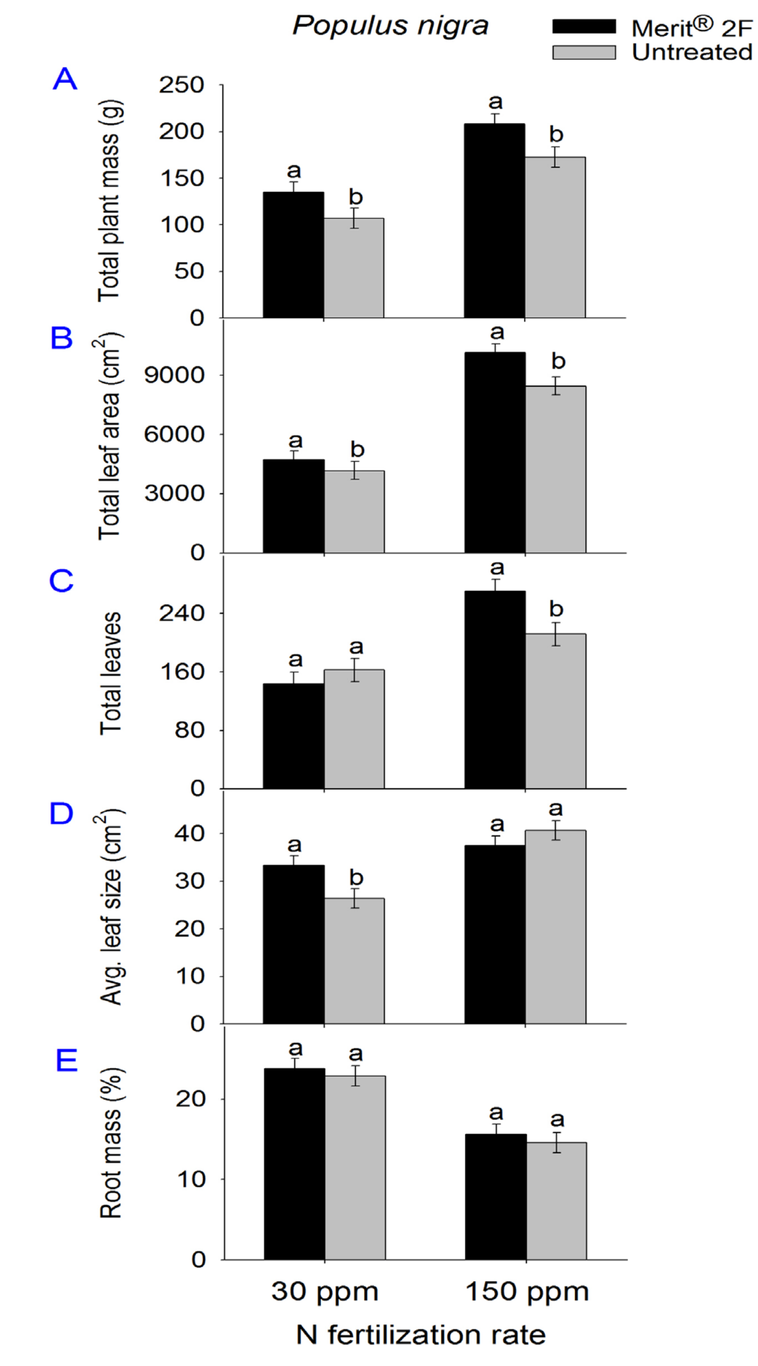


Figure 1. Effects of Merit® 2F and fertilization rate on growth and biomass allocation (A - E) of *Populus nigra* before dry-down period (least square mean ± SE). Means within a fertility treatment with the same letter are not significantly different (ANOVA followed by LSD test, p<0.05).

Merit® 2F increased fecundity of twospotted spider mite on *E. alatus* in the low nutrient regime, the same level observed in the high fertility treatment (Fig. 2).

Merit® 2F decreased larval growth and survival of fall webworm on *B nigra, S. sericea*, and *P. nigra*, and imported willow leaf beetle on the two last species (Figs. 3 & 4).

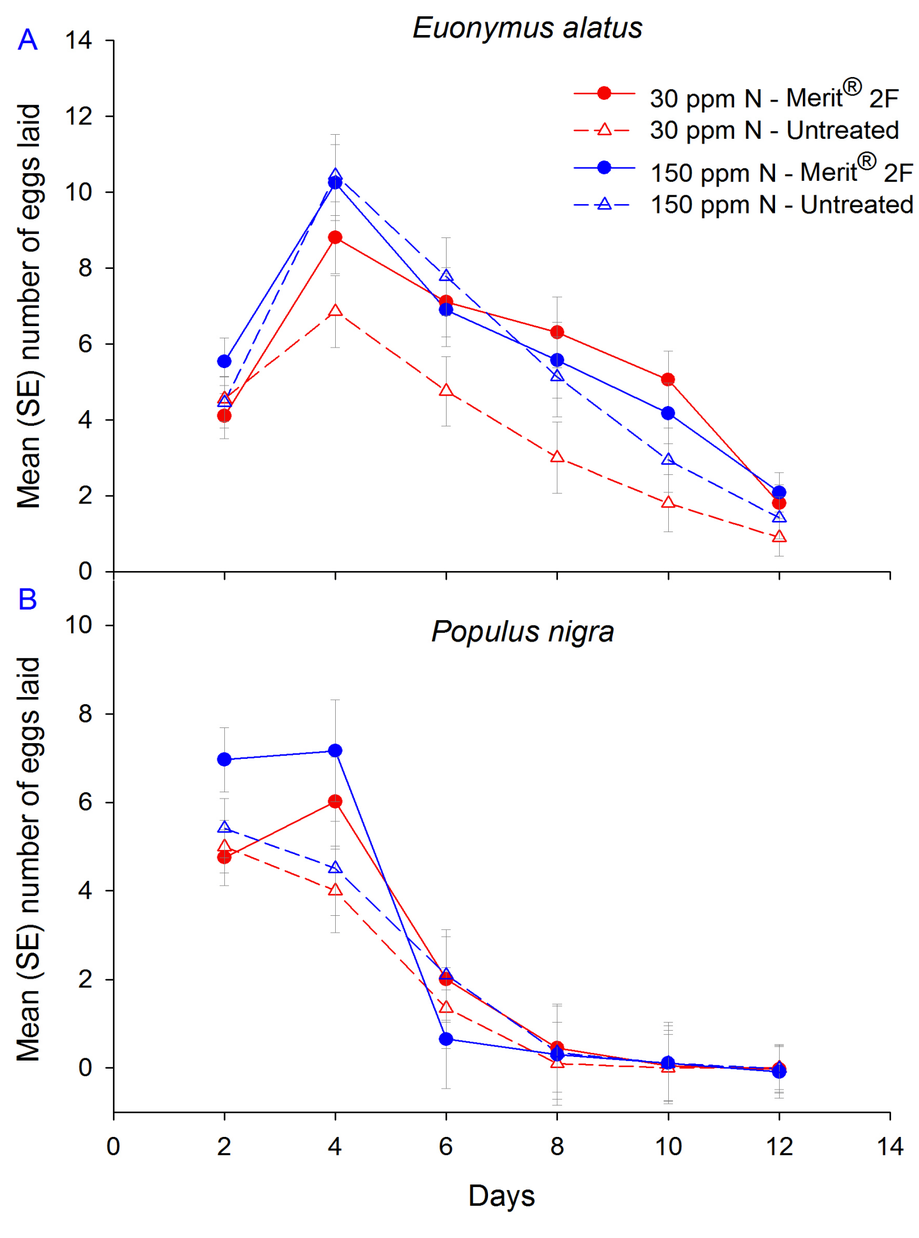


Figure 2. Effects of Merit® 2F on mean fecundity (mean eggs laid per 2 female) of twospotted spider mite on *Euonymus alatus* (A), and *Populus nigra* (B) during a period of 12 days (least square mean ± SE).

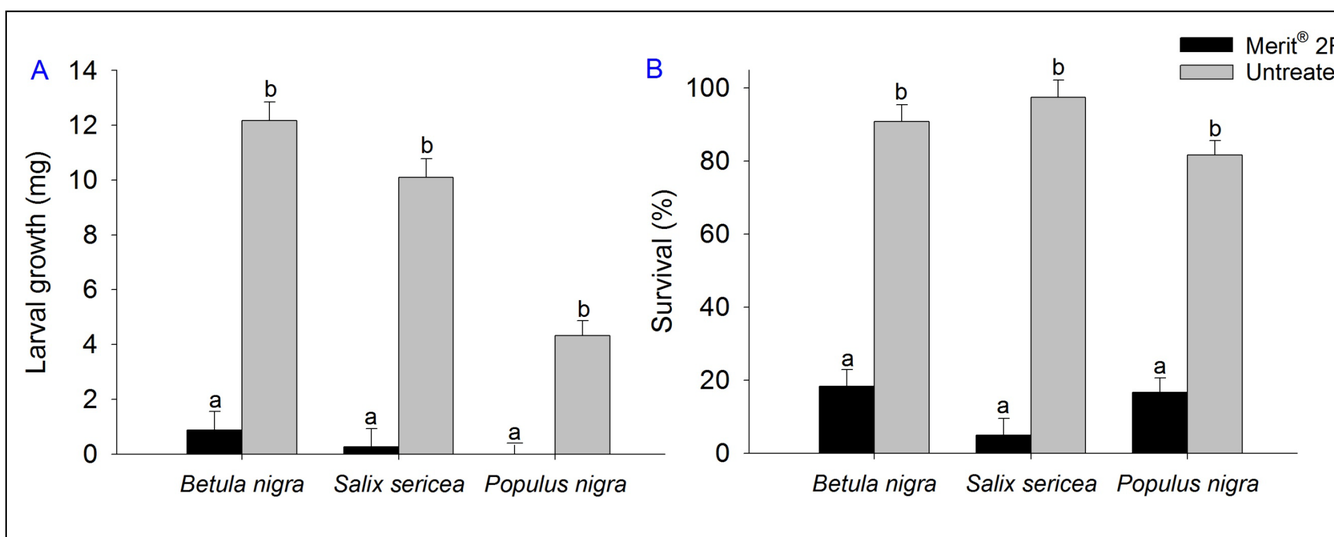


Figure 3. Effects of Merit® 2F on larval growth (A) and percent survival (B) of fall webworm on *Betula nigra, Salix sericea,* and *Populus nigra* after 7 days (least square mean ± SE). Means within the imidacloprid treatment with the same letter are not significantly different (ANOVA followed by LSD test, p<0.05).

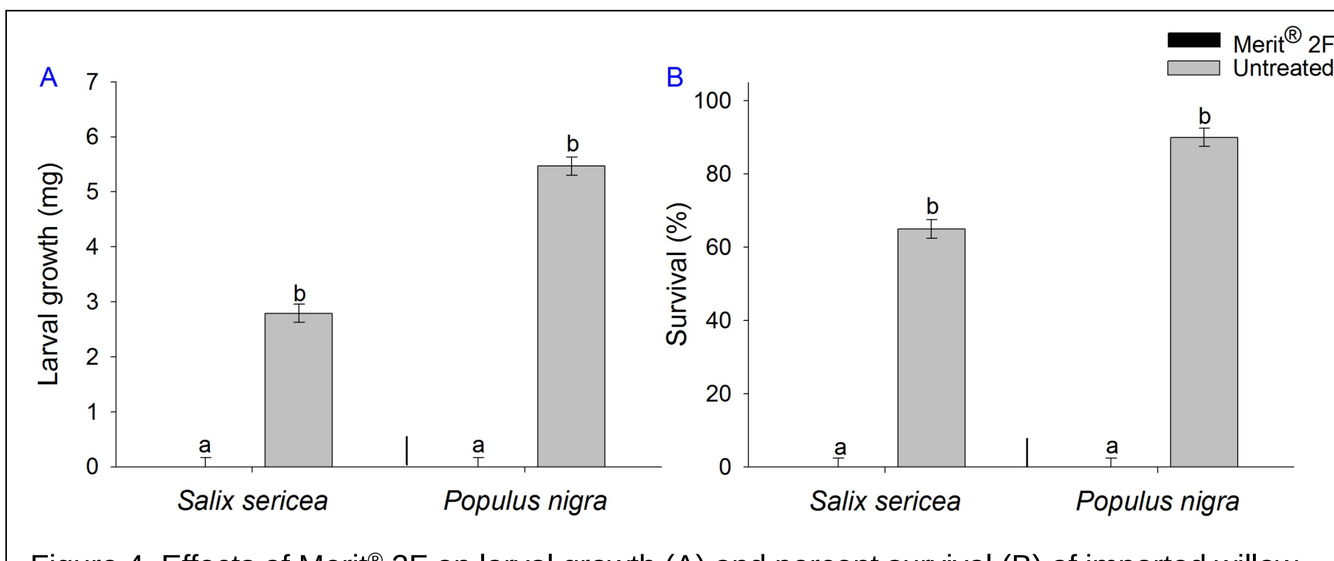


Figure 4. Effects of Merit® 2F on larval growth (A) and percent survival (B) of imported willow leaf beetle on *Salix sericea* and *Populus nigra* after 7 days (least square mean ± SE). Means within the imidacloprid treatment with the same letter are not significantly different (ANOVA followed by LSD test, p<0.05).

Conclusions

- Imidacloprid (Merit® 2F) increased the growth of *P. nigra* under optimal environments through physiological effects that are independent of its insecticidal properties. This positive effect varied depending on the rate of fertilization.
- Imidacloprid had no effect on growth of river birch, burning bush, or willow indicating that growth-enhancing effects are species specific.
- Imidacloprid increased fecundity of spider mites on low but not high fertility plants. Conversely, imidacloprid has strong insecticidal effects on imported willow leaf beetle, and surprisingly, fall webworm.

Literature Cited

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